EPA AOC Submission No. 2
Whelan, Joseph
to:
Bret Moxley, Stephen Tyahla, stuart.yamada
02/04/2011 01:07 PM
Show Details

History: This message has been replied to.

Greetings all.

Please find attached an electronic version of the work plans and reports that are due today as a result of the terms of the Administrative Order on Consent (AOC). Hard copies of each submittal were sent to you by certified mail dated February 4, 2011. Please let me know if you have any questions. We look forward to receiving your approval.

Best regards, <<DOCWGSL EPA AOC SUBMISSION 2.pdf>> <<DOCWGSL EPA AOC SUBMISSION 2 second set.pdf>>

Joe Whelan

General Manager

Waste Management of Hawaii

808-668-2985, ext. 15 Office

808-668-1366 Fax

808-479-4610 Mobile

Waste Management's landfills provide over 17,000 acres of protected land for wildlife habitats and 15 landfills are certified by the Wildlife Habitat Council.

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WASTE MANAGEMENT
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February 4, 2011

Bret Moxley
U.S. Environmental Protection Agency
Region IX (SFD-9)
75 Hawthorne Street
San Francisco, CA 94105

Stephen Tyahla
U.S. Environmental Protection Agency
Region IX (WST-5)
75 Hawthorne Street
San Francisco, CA 94105

Stuart Yamada, P.E., Chief
Environmental Management Division
Hawaii Department of Health
919 Ala Moana Blvd., Room 300
Honolulu, HI 96814-4920

RE: Administrative Order on Consent Submittal No. 2
Temporary Berm Stability Analysis, Cell E6 Liner Repair
Waimanalo Gulch Sanitary Landfill

Dear Mr. Moxley, Mr.Tyahla, & Mr. Yamada:

Waste Management of Hawaii, Inc. (WMH), the operator of the Waimanalo Gulch Sanitary Landfill (WGSL), is hereby submitting the work plans addressing Section 19a. (Temporary Berm Stability Analysis), and Section 19f. (Cell E6 Liner Repair) contained within the recently signed Administrative Order on Consent for Removal Action (AOC).

Please contact me at (808) 668-2985 with any questions or comments on this submission. We look forward to your approval.

Sincerely,
Joseph R. Whelan
General Manager
Waste Management of Hawaii, Inc.

cc: Mr. Wayne Hamada (City and County of Honolulu)
File

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2 February 2011

Mr. Richard T. Von Pein, P.E.
Waste Management
9081 Tujunga Avenue
Sun Valley, CA 91352

RE: Waimanalo Gulch Landfill
Slope Stability Analysis and Work Plan for Temporary Earthen Berm Integrity

Dear Mr. Von Pein:

As requested, Geosyntec Consultants, Inc. (Geosyntec) has evaluated the stability of the temporary berm first constructed in mid-December and then upgraded mid-January 2011 by Goodfellow Brothers, Inc. (GBI) at the request of Waste Management of Hawaii, Inc. (WMH). The berm was constructed as a temporary measure to control surface water. The berm will be removed during construction of the next phase of the West Berm estimated to start in 6 weeks. Figure 1 shows the approximate location of the berm.

This workplan is a required element of the "Work" pursuant to Section 19.a of the Administrative Order on Consent for Removal Action, CERCLA Docket No. 09-20111-0007/RCRA Docket No. 7003-09-2011-0001.

INFORMATION AVAILABLE ON TEMPORARY BERM CONSTRUCTION

In mid-January 2011, GBI and a WMH engineer visited the site and observed that the exposed (south) side of the temporary berm showed no signs of seepage, bulging, or cracking. Also, at this time, at WMH's direction, the berm's top width was increased and the exposed downstream (south) side slope was flattened.

On 24 January 2011, GBI provided spot elevations of the constructed berm to Geosyntec (see Figure 1). Geosyntec used this information to develop a topographic map for the berm. Geosyntec also used the topographic map in the area dated June 7, 2010 and the as-built grades for the E6 cell also shown in Figure 1. Based on the information provided in January 2011 for the as-built berm described above, in general the following were noted:

- The upstream (i.e., water storage side) steepest slope of the berm is approximately 1.8:1 (horizontal to vertical).
- The downstream (i.e., downstream side) steepest slope of the berm is approximately 3.5:1 (horizontal to vertical).
- The crest of the berm is approximately 50 feet wide and is approximately 120 feet long.
- The temporary berm was constructed above Phase 2 of the West Berm.

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The above dimensions varied locally as shown in Figure 1.

Based on the information provided by GBI we understand the berm was constructed by placing on-site material in 4-foot-thick lifts and "track walked by a D9 Dozer."

INPLACE MATERIAL PROPERTIES

It is Geosyntec's understanding that the temporary berm was constructed using on-site borrow sources consisting of crushed basalt. This material was placed by end dumping and compacting with a dozer. The dry unit weight of the material, evaluated in the field by GBI, was estimated to be approximately 115 pounds per cubic foot (pcf); the unit weight of the crushed basalt appears reasonable based on information in the Earth Manual[1]. The estimated shear strength friction parameter for this soil will be approximately 35 degrees and no cohesion[2].

According to the Construction Quality Assurance (CQA) report prepared by AECOM[3], the West Berm was comprised of onsite well-graded sandy cobble (non-plastic) borrow material. Only non-plastic material was approved for the West Berm rockfill. The rockfill was placed in loose lifts, visually observed to be 4.5-ft-thick. The loose lift was compacted using a CA 362 Dynapac vibratory compactor set to 1,900 vibrations per minute. Each lift was compacted using a minimum of 6 passes based on the criteria established by the rockfill test pads. Before placing the next lift, the completed rockfill lift was scarified to promote cohesion with the next lift. The method used met the requirements described under test fill pad in AECOM's CQA report. Based on data collected during construction, a dry unit weight of 135 pcf was used for the evaluation with a shear strength friction parameter of approximately 38 degrees and no cohesion.

As discussed above, the steepest surveyed temporary berm slope was 1.8:1 (horizontal to vertical) on the north (upstream) side and 3.5:1 (horizontal to vertical) on the south (downstream) side. The top width was about 50 feet.

---

[1] *Earth Manual*, United States Department of the Interior, Bureau of Reclamation, A Water Resources Technical Publication, Second Edition, 1974.

[2] *Design of Small Dams*, United States Department of the Interior, Bureau of Reclamation, A Water Resources Technical Publication, Third Edition, 1987.

[3] *Construction Quality Assurance Report for West Berm Construction (Interim)*, Waimanalo Gulch Landfill, Kapolei, Oahu, Hawaii, prepared for Waste Management of Hawaii, Inc., prepared by AECOM, February 2010.

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SLOPE STABILITY ANALYSES FOR THE AS-BUILT TEMPORARY BERM

Slope stability analyses were performed using the SLOPE/W computer program and Spencer Method of Slices stability analyses. Slope stability was analyzed considering the following two conditions for the upstream (north) and downstream (south) slopes:

1) Moist soil, no water stored, no phreatic surface.
2) Saturated soil below a steady-state phreatic surface, and water stored to 1 foot below the top of the crest of the berm.

For these conditions, the calculated factors of safety are tabulated below:

Soil and Water Conditions	Factors of Safety	
	Upstream (north)	Downstream (south)
Moist soil (no water stored upstream) and no phreatic surface	1.3 (Figure 2)	2.4 (Figure 4)
Saturated soil below the water surface with water stored (upstream) and phreatic surface developed (downstream)	1.3 (Figure 3)	1.6 (Figure 5)

Figure 1 shows the as-built contours of the temporary berm and the analyzed cross section. Figures 2, 3, 4, and 5 show the output for the analyzed cross sections for the temporary berm[4].

Based on the information provided by WMH and GBI, for the cases analyzed, the factor of safety (FS) is equal to or greater than the generally-accepted value of 1.3 under temporary conditions. Therefore, the temporary earthen berm is stable under the conditions analyzed.

WORK PLAN FOR TEMPORARY BERM INTEGRITY

Because the temporary berm meets or exceeds minimum accepted factors of safety, WMH does not plan to modify the berm further at this time. It is Geosyntec's understanding that the west

[4] The sudden drawdown condition for the upstream face has not been evaluated because it has been assumed that the berm material is cohesionless (free-draining) and WMH will lower the pond level at a rate that will be slow enough that excess pore pressures will not be generated.

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diversion channel will be functionally operational in approximately ten days eliminating the need for the temporary berm. Further the berm will be replaced by an extension of the west stability berm within 6 weeks.

Please contact us if there are further questions.

Sincerely yours,

Hari D. Sharma

Hari D. Sharma, Ph.D., P.E.
Principal

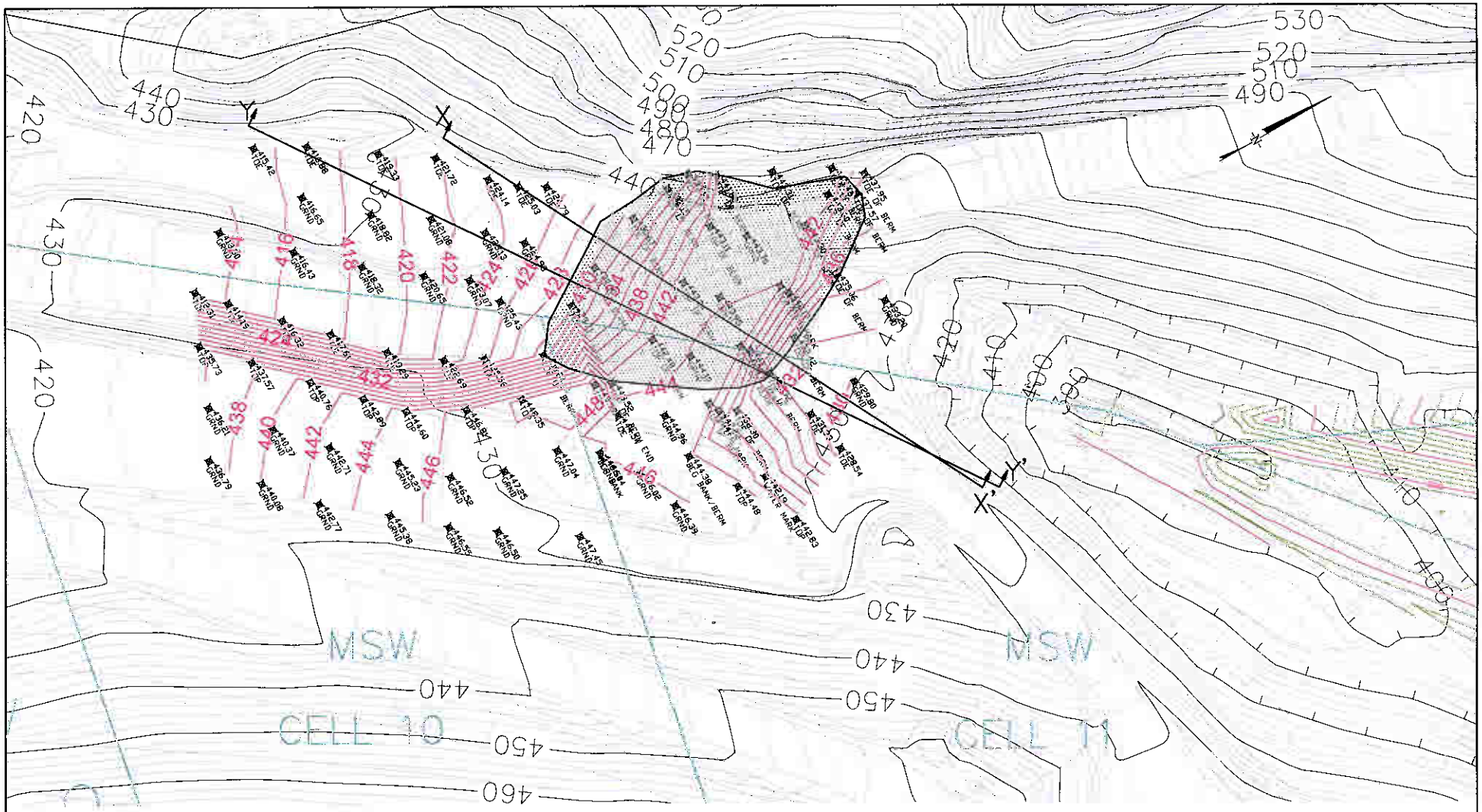
ATTACHMENTS

Figure 1: Temporary Berm As-Built Grades and Cross Sections
Figure 2: Temporary Berm Stability: Upstream Slope, Moist Soil
Figure 3: Temporary Berm Stability: Upstream Slope, Stored Water
Figure 4: Temporary Berm Stability: Downstream Slope, Moist Soil
Figure 5: Temporary Berm Stability: Downstream Slope, Phreatic Surface (Steady-state)

COPY TO

Mr. Joseph Whelan (WMH)
Mr. Jesse Frey (WMH)

FIGURES



NOTES:

1. TOPOGRAPHY DATED 7 JUNE 2010.
2. DATA POINTS PROVIDED BY GBI ON 24 JANUARY 2011 AND 25 JANUARY 2011.

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TEMPORARY BERM AS-BUILT GRADES AND CROSS SECTION LOCATIONS
WAIMANALO GULCH LANDFILL
EWA BEACH, OAHU, HAWAII

FIGURE NO.	1
PROJECT NO.	WL0770
DATE:	FEBRUARY 2011

Figure 2 - Temporary Berm Stability: Upstream Slope, Moist Soil

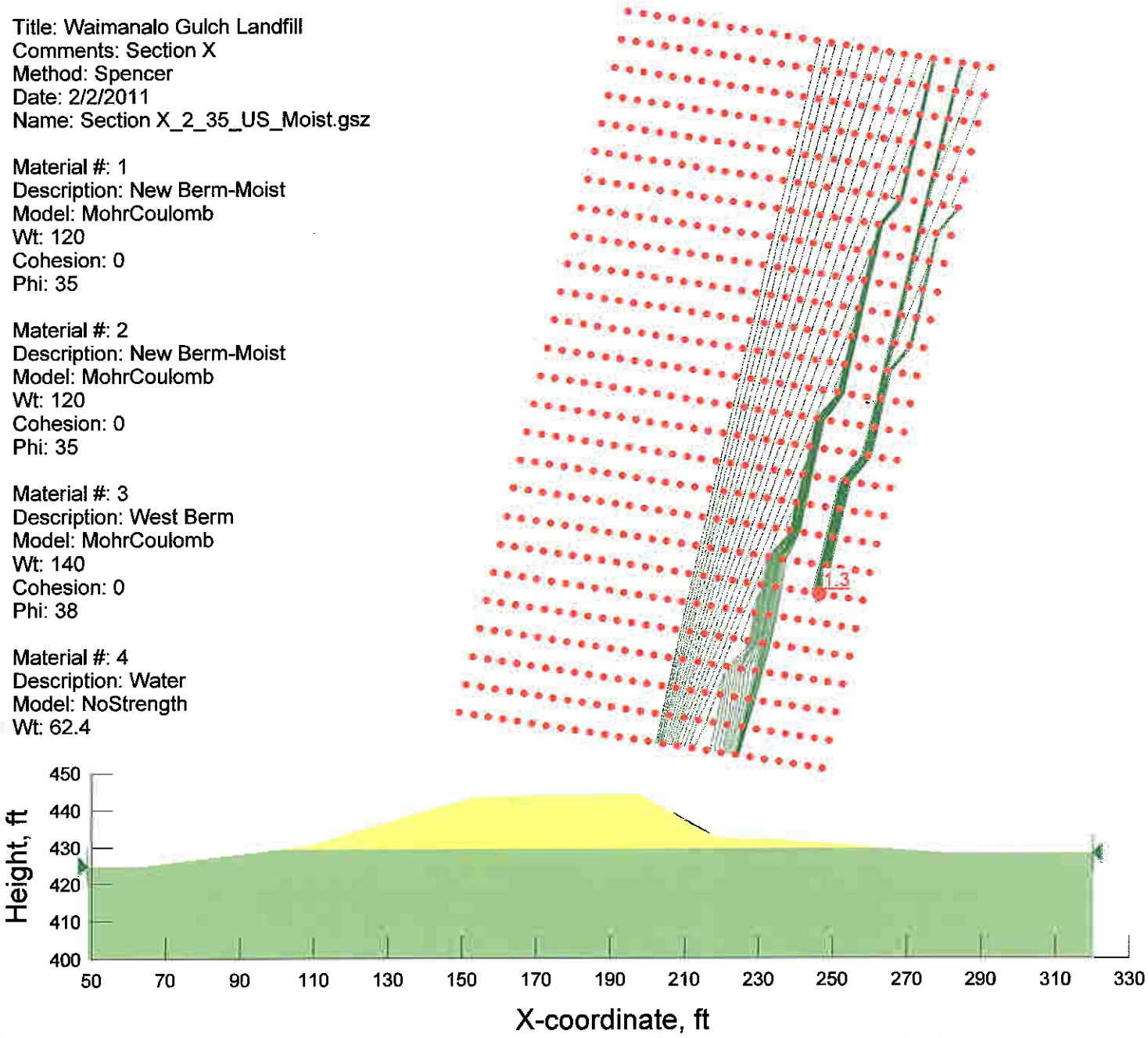
Title: Waimanalo Gulch Landfill
Comments: Section X
Method: Spencer
Date: 2/2/2011
Name: Section X_2_35_US_Moist.gsz

Material #: 1
Description: New Berm-Moist
Model: MohrCoulomb
Wt: 120
Cohesion: 0
Phi: 35

Material #: 2
Description: New Berm-Moist
Model: MohrCoulomb
Wt: 120
Cohesion: 0
Phi: 35

Material #: 3
Description: West Berm
Model: MohrCoulomb
Wt: 140
Cohesion: 0
Phi: 38

Material #: 4
Description: Water
Model: NoStrength
Wt: 62.4



Directory: P:\PRJ2003Geo\WMI\Waimanalo\WL0770\Related to USEPA (2011)\Slope Stability Berm-Jan 2011\

Figure 3 - Temporary Berm Stability: Upstream Slope, Stored Water

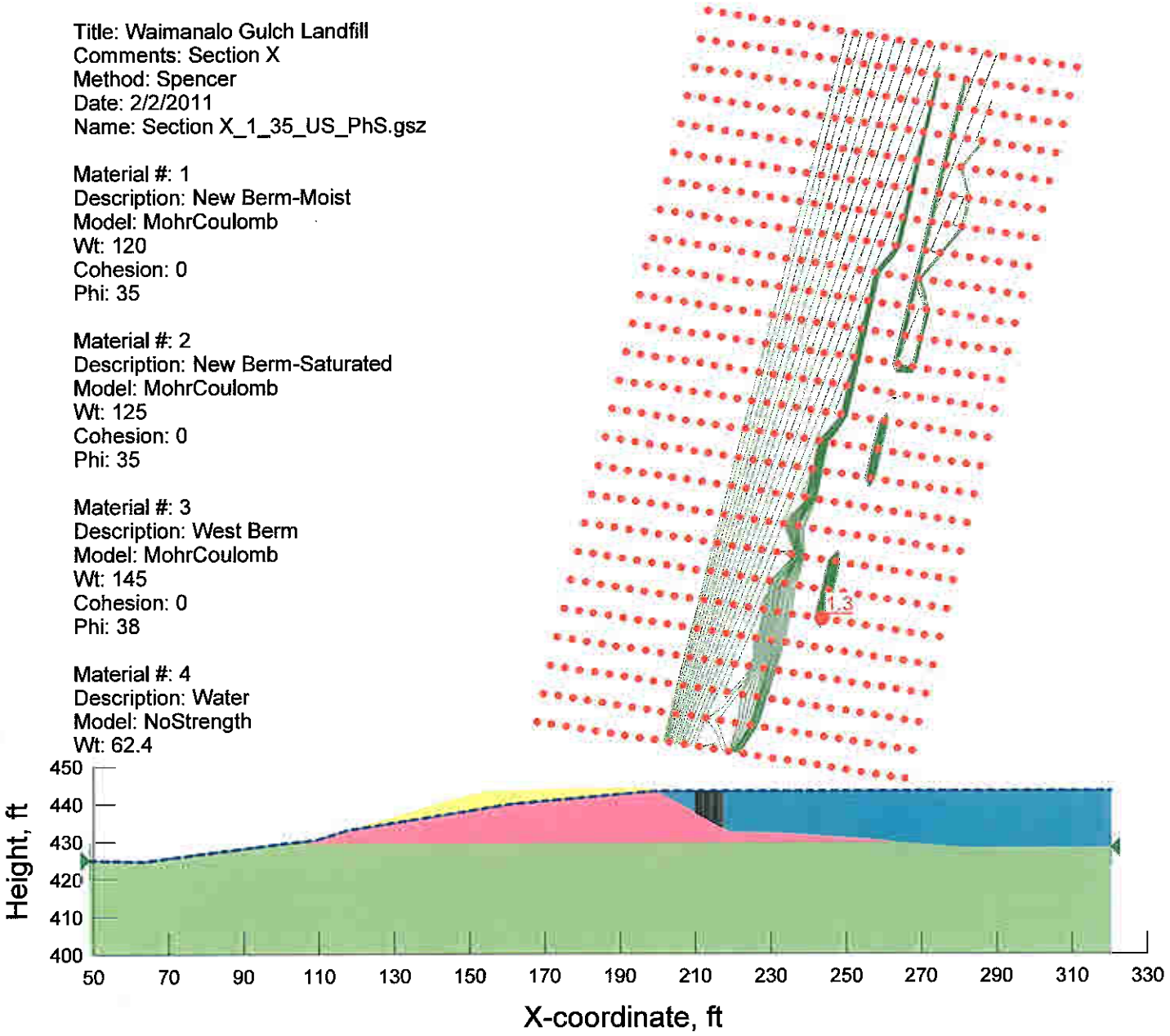
Title: Waimanalo Gulch Landfill
Comments: Section X
Method: Spencer
Date: 2/2/2011
Name: Section X_1_35_US_PhS.gsz

Material #: 1
Description: New Berm-Moist
Model: MohrCoulomb
Wt: 120
Cohesion: 0
Phi: 35

Material #: 2
Description: New Berm-Saturated
Model: MohrCoulomb
Wt: 125
Cohesion: 0
Phi: 35

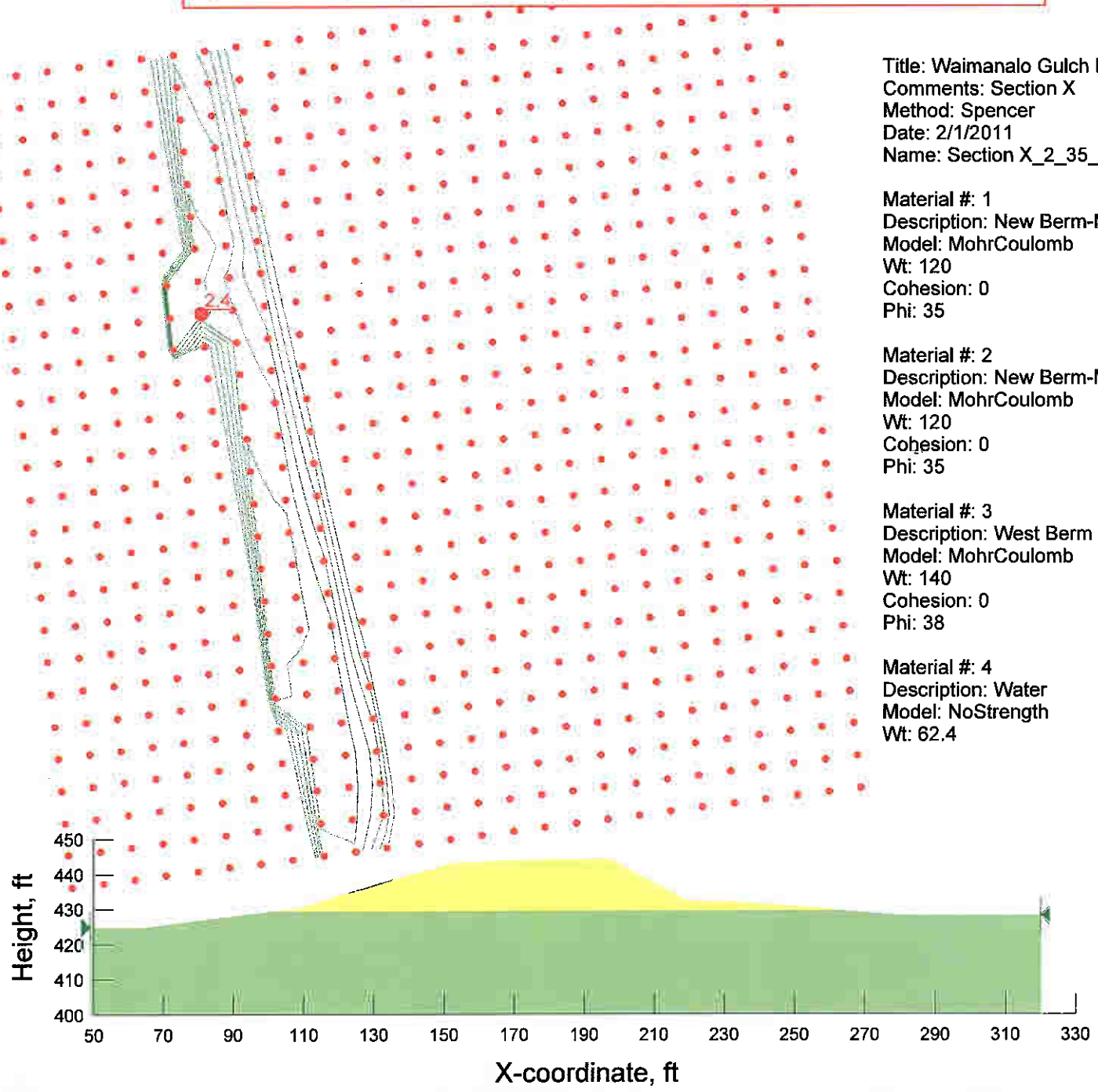
Material #: 3
Description: West Berm
Model: MohrCoulomb
Wt: 145
Cohesion: 0
Phi: 38

Material #: 4
Description: Water
Model: NoStrength
Wt: 62.4



Directory: P:\PRJ2003Geo\WMI\Waimanalo\WL0770\Related to USEPA (2011)\Slope Stability Berm-Jan 2011\

Figure 4 - Temporary Berm Stability: Downstream Slope, Moist Soil



Title: Waimanalo Gulch Landfill
Comments: Section X
Method: Spencer
Date: 2/1/2011
Name: Section X_2_35_DS_Moist.gsz

Material #: 1
Description: New Berm-Moist
Model: MohrCoulomb
Wt: 120
Cohesion: 0
Phi: 35

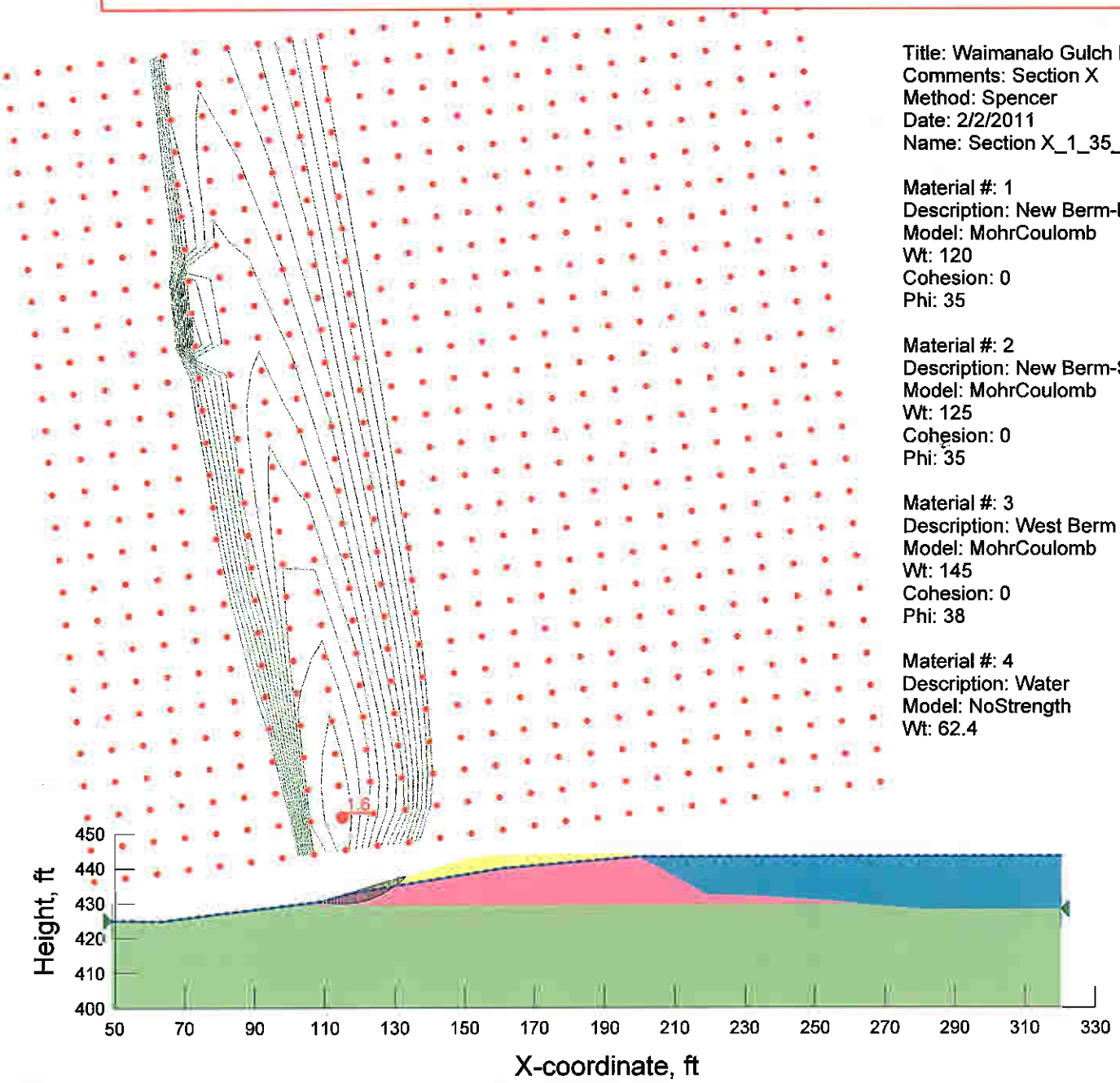
Material #: 2
Description: New Berm-Moist
Model: MohrCoulomb
Wt: 120
Cohesion: 0
Phi: 35

Material #: 3
Description: West Berm
Model: MohrCoulomb
Wt: 140
Cohesion: 0
Phi: 38

Material #: 4
Description: Water
Model: NoStrength
Wt: 62.4

Directory: P:\PRJ2003Geo\WMI\Waimanalo\WL0770\Related to USEPA (2011)\Slope Stability Berm-Jan 2011\

Figure 5 - Temporary Berm Stability; Downstream Slope, Phreatic Surface (Steady-state)



Title: Waimanalo Gulch Landfill
Comments: Section X
Method: Spencer
Date: 2/2/2011
Name: Section X_1_35_DS_PhS.gsz

Material #: 1
Description: New Berm-Moist
Model: MohrCoulomb
Wt: 120
Cohesion: 0
Phi: 35

Material #: 2
Description: New Berm-Saturated
Model: MohrCoulomb
Wt: 125
Cohesion: 0
Phi: 35

Material #: 3
Description: West Berm
Model: MohrCoulomb
Wt: 145
Cohesion: 0
Phi: 38

Material #: 4
Description: Water
Model: NoStrength
Wt: 62.4

Directory: P:\PRJ2003Geo\WMI\Waimanalo\WL0770\Related to USEPA (2011)\Slope Stability Berm-Jan 2011\

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27 January 2011

Mr. Richard T. Von Pein, P.E.
Waste Management
9081 Tujunga Avenue
Sun Valley, CA 91352

RE: Waimanalo Gulch Landfill
Workplan for Liner Evaluation and Repair

Dear Mr. Von Pein:

As requested by Waste Management of Hawaii, Inc (WMH), Geosyntec Consultants, Inc. (Geosyntec) has prepared a workplan to evaluate the damaged liner system and proposed repair methodology in the expansion area at the Waimanalo Gulch Landfill (Landfill) that may have been damaged due to storms in December 2010 and January 2011. This workplan is a required element of the "Work" pursuant to Section 19.f of the Administrative Order on Consent for Removal Action, CERCLA Docket No. 09-20111-0007/RCRA Docket No. 7003-09-2011-0001.

For reference, the liner system on the side slopes of the expansion area of the Landfill, from bottom to top, consists of:

- Subgrade;
- Soil cushion layer;
- Encapsulated geosynthetic clay liner (GCL) composite liner system consisting of:

  (i) 40-mil-thick high density polyethylene (HDPE) geomembrane (textured on both sides),
  (ii) GCL (reinforced, needle-punched, with 2 nonwoven geotextile carriers), and
  (iii) 60-mil-thick HDPE geomembrane (textured on both sides);
- 16-ounce nonwoven cushion geotextile; and
- Operations layer.

For the floor areas, all the components are the same as for the side slopes, except that a 1-foot-thick gravel layer overlain by a separator nonwoven geotextile is between the cushion geotextile and the operations layer.

WORKPLAN

WMH provided Geosyntec a set of photographs, attached herein (Attachment A), that show the conditions of the liner system at various locations after the rainstorms.

Based on these attached photographs, the following two conditions are apparent:

1) Areas of liner that are damaged and that need to be completely reconstructed.
2) Areas of liner that appear undamaged but that need to be carefully inspected.

For these two conditions the following activities that need to be performed are described below.

DAMAGED LINER AREAS THAT NEED TO BE COMPLETELY RECONSTRUCTED

For these areas, the liner system components will need to be completely removed to the soil cushion layer and replaced with material conforming with the project specifications. The soil cushion layer will also need to be assessed for damage and repaired if needed.

LINER AREAS THAT APPEAR UNDAMAGED

For these areas, the various components of the liner system (i.e., the soil cushion layer, the 40-mil HDPE geomembrane, the GCL, and the 60-mil HDPE geomembrane) will need to be carefully inspected to ensure that liner components are not damaged and the bentonite in the GCL is not hydrated.

The following procedures should be implemented:

1. First, **the 60-mil HDPE geomembrane** will need to be inspected for gashes, cuts, and holes; if these are found, the GCL and the 40-mil HDPE geomembrane below the 60-mil HDPE geomembrane will also need to be inspected and the details of the damage need to be documented and the system repaired.

2. Since the liner system includes **an encapsulated GCL**, the GCL will need to be assessed for hydration. If hydration is suspected, cut open a sample of the partially hydrated GCL in question to expose and inspect the sandwiched bentonite. If the bentonite granules remain separate and fall out of the cut, then accept the partial hydration and patch the test area in accordance with the specifications. If the bentonite granules are swollen, stick together, or otherwise appear hydrated, then remove the hydrated GCL and replace with fresh, unaffected GCL.

3. After assessing the various GCL panels, the CQA consultantwill need to cut a piece of the GCL in the area of damage to verify that the **underlying 40-mil HDPE geomembrane** has not been damaged either.

4. All liner terminations should be carefully inspected for signs that water may have flowed below the liner system and may have damaged the underlying **soil cushion layer**. If this is observed the layer should be repaired.

REPAIR PROCEDURES

Attachment B presents the repair procedures for the various liner system components.

DOCUMENTATION

At each step for both conditions (i.e., damaged areas and areas that appear undamaged), documentation should consist of the following:

1) Panel layout showing damaged areas (both repairable and that need to be completely reconstructed).
2) Panel layout showing the type of damage.
3) Assessment of each layer (soil cushion, geomembranes, GCL).
4) Photographic documentation of the various layers.

Other documentation is presented in Attachment B. A construction quality assurance (CQA) report for the areas will need to be prepared and submitted to the regulatory agencies for approval.

SCHEDULE

Work along the east side has been completed and a CQA report has been submitted.

Work on the west side in ongoing; this schedule may need adjustment depending on the extent of damage uncovered in the field.

At this time, the E6 west liner slope will need to be divided into two sections labeled: northern portion and southern portion. The division is needed because access to the work area is restricted due to ongoing slope excavation above the northern area (i.e., loose debris on the cut slopes above constitutes a rockfall safety hazard).

Based on the current, general assessment, the scope of the work for the Southern Portion of E-6 West Liner Slope is:

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- The damaged area appears to be a wrinkle on the upper portion of the sideslope;
- The General Contractor will place fill material over muddy areas of the cell to create access for personnel and equipment from now through this weekend (i.e., 1/27 and 1/30);
- On Monday (1/31) assessment of the damaged area will begin with repairs to follow; and
- Repair work is expected to take up to one week.

The scope of the work for the Northern Portion of the E-6 West Liner Slope is:

- It will take the General Contractor approximately 45 days to remove and mitigate the rockfall safety hazards;
- Assessment of this area will commence after the 45 days required to mitigate safety hazards; and
- The repair work for the damaged liner areas is expected to take 3 weeks.

Please contact us if there are further questions.

Sincerely yours,

Hari D. Sharma

Hari D. Sharma, Ph.D., P.E.
Principal

ATTACHMENTS

A - Damaged Liner Photos
B – Repair Procedures for Liner Components

COPY TO

Mr. Joseph Whelan (WMH)
Mr. Jesse Frey (WMH)

ATTACHMENT A
DAMAGED LINER PHOTOS


01/19/2011


01/19/2011


01/19/2011


01/19/2011


01/19/2011


01/19/2011


01/19/2011


01/19/2011


01/19/2011


01/19/2011


01/19/2011

ATTACHMENT B
REPAIR PROCEDURES FOR LINER COMPONENTS

ATTACHMENT B
REPAIR PROCEDURES FOR LINER SYSTEM COMPONENTS

The following liner system components may need to be repaired or replaced at the Waimanalo Gulch Landfill based on inspection performed by the Owner and the construction quality assurance (CQA) consultant:

- Geotextile
- Geosynthetic clay liner
- Geomembranes (40-mil-thick and 60-mil-thick)
- Soil cushion layer

GEOTEXTILE REPAIR

MATERIAL, EXAMINATION, AND PROTECTION

A. Use materials that have been approved by OWNER for the construction of Cells E5 through E8.

B. Prior to installation of geotextile, examine underlying construction for conformance with specifications.

C. When placing soil materials over geotextile ensure the following:
   1. No damage to geotextile.
   2. No slippage of geotextile on underlying layers.
   3. No excessive tensile stresses in the geotextile.
   4. Meet ground pressure requirements listed below:

Maximum Equipment Ground Pressure (psi)	Initial Lift Thickness (ft)
5	1.0
10	1.5
20	2.0
>20	>3.0

DEPLOYMENT

A. Roll geotextile down slope keeping the geotextile sheet in sufficient tension to prevent folds and wrinkles.
B. Weight geotextile with sandbags, or equivalent, to ballast during deployment. Leave ballast in place until geotextile is covered with succeeding construction layer.
C. Do not trap dust, stones, or moisture in geotextile that could damage or clog drains or filters, or hamper subsequent seaming.
D. Examine geotextile over entire completed surface to ensure that no potentially harmful foreign objects, such as needles, are present. Remove any foreign objects.

SEAMS AND OVERLAPS

A. Sew all seams for geotextiles. Overlap geotextile 3 inches minimum prior to seaming. Do not seam horizontally on slopes steeper than 10 percent (i.e., seam along, not across slopes). All seams shall be either "double prayer" or "single J" seam.
B. Ensure that no soil materials are inadvertently inserted beneath the seams of geotextiles.
C. Sew with polymeric thread having chemical resistance and strength properties equal to or exceeding those of geotextile.
D. For sewing, use a 401 two-thread chain stitch, or equivalent.

REPAIRS

A. Repair holes or tears in geotextiles with a patch from the same geotextile material, sewn in place with a minimum seam overlap of 12 inches in all directions. Sew the geotextile within 1 inch of the outside edge of the patch materials. If tear exceeds 50 percent of the roll width, remove and replace the roll. No patches will be allowed within 1 inch of a panel edge.
B. Remove any soil or other material which may have penetrated the torn geotextile.

DOCUMENTATION

A. The repair is considered completed when all of the items below have been

performed:

1. The installation is complete.
3. Documentation of installation is complete including the final report.
4. Verification of the adequacy of all seams and repairs, including associated testing, is complete.
5. Written certification documents have been received by the OWNER.

GEOSYNTHETIC CLAY LINER REPAIR

MATERIAL, EXAMINATION, AND PROTECTION

A. Use materials that have been approved by OWNER for the construction of Cells E5 through E8.

B. The GCL shall be deployed in the field in the same configuration/orientation as the material that is being replaced or repaired.

C. When ready to deploy/install the GCL, the GCL shall have a moisture content less than or equal to the initial moisture content reported for the GCL.

D. The INSTALLER shall handle all geosynthetic clay liners in such a manner to prevent any damage.

E. In the presence of wind, all geosynthetic clay liners shall be sufficiently weighted with sandbags to prevent their movement.

F. Geosynthetic clay liners shall be cut using a utility blade in a manner that the materials (GCL and the adjacent geosynthetics) are not damaged. Any damage to any underlying liner system components during cutting will be repaired at no cost to the Owner.

G. During placement, care shall be taken not to entrap stones or moisture under the geosynthetic clay liner. Care shall be taken not to walk on or drag equipment across the exposed geosynthetic clay liner.

H. Any geosynthetic clay liner damaged by stones or other foreign objects, or by installation activities, shall be replaced at no additional cost to the OWNER.

I. The geosynthetic clay liner shall not be installed on a saturated or excessively moist subgrade or on standing water. The geosynthetic clay liner shall be installed in a way that prevents hydration of the mat prior to completion of construction of the liner system.

J. The geosynthetic clay liner shall not be installed during precipitation or other conditions that may cause hydration of the geosynthetic clay liner.

K. Geomembrane installation shall immediately follow the geosynthetic clay liner installation. All geosynthetic clay liner that is placed during a day's work shall be covered with geomembrane and ends and corners protected against potential moisture and water migration before the INSTALLER leaves the site at the end of the day.

L. Geomembrane shall not be placed on a geosynthetic clay liner that is hydrated.

M. All geomembrane seams shall be welded after each geomembrane panel is placed over the geosynthetic clay liner. Heat sealing of seams for geomembrane placed over bentonite matting alone is not acceptable.

N. All geomembrane defects and destructive sample locations shall be immediately repaired to protect the underlying geosynthetic clay liner.

O. The INSTALLER shall ensure that the geosynthetic clay liner is not damaged while working around the appurtenances such as riser pipes.

SEAMS AND OVERLAPS

A. On slopes steeper than 10 horizontal to 1 vertical, all geosynthetic clay liners shall be continuous down the slope; that is, no horizontal seams shall be allowed on the slope.

B. No horizontal seams shall be allowed on the base and the crest of the landfill within 5 ft (1.5 m) of the toe or the crest of the slope.

C. All geosynthetic clay liners shall be overlapped in accordance with the Manufacturer's recommended procedures. As a minimum, along the length (i.e., the sides) of the mat, the overlap shall be 18 inches. Along the width (i.e., the ends) of the mat, the overlap shall be 18 inches; longer overlaps may be needed to match undamaged liner.

D. The overlaps shall not be nailed or stapled to the subgrade.

E. Granular bentonite shall be placed on the overlaps.

REPAIRS

A. Any holes or tears in the geosynthetic clay liner shall be repaired by placing a geosynthetic clay liner patch over the hole. On slopes greater than 5 percent, the patch shall overlap the edges of the hole or tear by a minimum of 2 ft (0.6 m) in all directions. On slopes 5 percent or flatter, the patch shall overlap the edges of the hole or tear by a minimum of 1 ft (0.3 m) in all directions. The patch shall be secured with a

water-based adhesive, if approved by the MANUFACTURER.

B. Care shall be taken to remove any soil or other material which may have penetrated the torn geosynthetic clay liner.

C. All repairs shall be made at no additional cost to the OWNER.

D. The patch shall not be nailed or stapled.

DOCUMENTATION

A. The repair is considered completed when all of the items below have been performed:

1. The installation is complete.
3. Documentation of installation is complete including the final report.
4. Verification of the adequacy of all seams and repairs, including associated testing, is complete.
5. Written certification documents have been received by the OWNER.

GEOMEMBRANE REPAIR

MATERIAL, EXAMINATION, AND PROTECTION

A. Use materials that have been approved by OWNER for the construction of Cells E5 through E8.

B. The geomembranes shall be deployed in the field in the same configuration/orientation as the material that is being replaced or repaired.

C. Verify in writing to the OWNER that the surface on which the geomembrane will be installed is acceptable.

D. Grade changes rounded to min. 6-inch radius.

E. No projections more than 0.25 inch in contact with the geomembranes are allowed. Contractor shall be prepared to roll the surface or use other methods to achieve this requirement.

F. The INSTALLER shall handle all geomembranes in such a manner to prevent any damage.

PREPARATION

A. Repair damage caused to subgrade during deployment.

B. Round edges of anchor trenches or cushion with geotextiles.

C. Perform trial seam welds as follows:

1. Perform trial welds on samples of geomembrane to verify the performance of welding equipment, seaming methods, and conditions.
2. No seaming equipment or welder will be allowed to perform production welds until equipment and welders have successfully completed trial welds.
3. Frequency of trial welds:
    a. Minimum of two trial welds per day with one prior to the start of work and one at mid shift.
    b. When directed by the Construction Quality Assurance Monitor.
    c. Every 2 hours when using a wedge weld to weld across seams.
    d. Minimum one trial weld per person per shift.
    e. When ambient temperature changes more than 10°F since previous trial weld.
4. Make trial welds in the same surroundings and environmental conditions as the production welds, i.e., in contact with subgrade.
5. Make trial weld sample at least 5-feet-long and 12-inches-wide with the seam centered lengthwise.
6. Cut two, 1-inch-wide test strips from opposite ends of the trial weld.
7. Quantitatively test specimens, first for peel adhesion, and then for bonded seam strength (shear) (ASTM D6392).
    a. The break is a film tearing bond (FTB).
    b. The break is ductile.
    c. The peel and shear strengths meet the minimum requirements on Table 1 for wedge welded, flat welded, and/or extrusion welded seams and there is no more than 10 percent separation of the weld. For wedge welds the width of the weld is equal to the width of the nip roller.
    d. When testing set grips back 2 inches from the edge of the weld. Minimum elongation between the grips must be 2 inches.
9. A trial weld sample is considered passing when specimens pass peel and shear tests.
10. Repeat the trial weld in its entirety when any of the trial weld samples fail in either peel or shear.

11. When repeated trial weld fails, do not use welding apparatus and welder until deficiencies or conditions are corrected and two consecutive successful trial welds are achieved.

Table 1
REQUIRED GEOMEMBRANE SEAM PROPERTIES[1]

PROPERTIES	QUALIFIERS	SPECIFIED UNITS	TEST VALUES		METHOD
Gauge	Nominal	mils	40	60	--
Hot Wedge Shear Strength[2]	Minimum	lb/in	80	120	ASTM D 4437
Hot Wedge Peel Adhesion (Fusion and Extension)	Minimum	lb/in	60	91	ASTM D 4437
Extrusion Shear Strength[1]	Minimum	lb/in	80	120	ASTM D 4437
Extrusion Peel Adhesion (Fusion and Extension)	Minimum	lb/in	52	78	ASTM D 4437

Notes:
1 Based on GRI Test Method GM19.
2 Also called "Bonded Seam Strength."

INSTALLATION

A. Deployment.

1. Give careful consideration to the timing and temperature during deployment. The INSTALLER must verify that (a) there is no bridging or stresses in the geomembrane and (b) there are no wrinkles in the geomembrane that will fold over when covering with soil material. Ideally, deployment, welding, and covering should all occur at the same temperature. In a practical sense the INSTALLER should strive to perform these activities within as narrow a temperature range as practical, and avoid these activities during peak hot or cold conditions.
2. Panel Identification: Assign each panel an identifying code number of letter consistent with the INSTALLER's submitted panel layout drawing. The coding is subject to approval by the CQA Monitor.
3. Daily Panel Deployment: Deploy no more panels in one shift than can be welded or secured during that same shift.
4. Do not deploy in the presence of excessive moisture, fog, dew, precipitation, ponded water, or high winds.
5. Do not damage geomembrane by handling, by trafficking, or leakage of

hydrocarbons or any other means.

6. Do not wear damaging shoes or engage in activities that could damage the geomembrane.
7. Unroll geomembrane panels using methods that will not damage, stretch or crimp geomembrane. Protect underlying surface from damage.
8. Use methods that minimize wrinkles and differential wrinkles between adjacent panels.
9. Remove wrinkled or folded material.
10. Place ballast on geomembrane that prevents uplift from wind.
11. Use ballast that will not damage geomembrane.
12. Protect geomembrane in area of heavy traffic by placing protective cover which is compatible with and will not damage geomembrane.
13. Repair damage to subgrade or other underlying materials prior to completing deployment of geomembrane.
14. Do not allow any vehicular traffic directly on geomembrane.
15. Visually inspect geomembrane for imperfections. Mark faulty or suspect areas for repair.
16. Install material to account for shrinkage and contraction while avoiding wrinkles. Install material stress-free with no bridging before it is covered. Add material as needed to avoid bridging.
17. Before wrinkles fold over, attempt to push them out. For wrinkles that cannot be pushed out, cut them out and repair cuts prior to burial or at the direction of the CQA monitor.
18. Use slip sheet when deploying textured geomembrane over geotextiles to avoid damaging geotextile fibers. Slip sheet shall be removed after deployment.

B. Seam Layout.

1. Orient seams parallel to line of a maximum slope, i.e., orient down not across slope.
2. Minimize number of field seams in corners, odd shaped geometric locations and outside corners.
3. Keep horizontal seams (seams running approximately parallel to slope contours) at least 6 feet away from toe or crest of slope, unless approved by OWNER.
4. Use seam numbering system compatible with panel number system.

5. Shingle panels on all slopes and grades as directed by OWNER.

C. Seam Welding Personnel.

1. Provide at least one welder (master welder) who has experience welding over 5 million square feet of geomembrane using the same type of welding apparatus in use at site.
2. Qualify personnel performing welding operations by experience and by successfully passing field welding tests performed on site.
3. Master welder will provide direct supervision over other welders.

D. Seam Welding Equipment.

1. Extrusion welder: equipped with gauges showing temperatures in extruder apparatus and at nozzle. Temperature at nozzle may be measured by external temperature gauges.
2. Hot wedge welder: Automated variable speed vehicular mounted devices equipped with devices adjusting and giving temperatures at wedge. Pressure controlled by spring, pneumatic, or other system that allows for variation in sheet thickness. Rigid frame fixed position equipment is not acceptable.
3. Maintain adequate quality of welding apparatus in order to avoid delaying the project.
4. Use power source capable of providing constant voltage under combined line load.

E. General welding procedures:

1. Do not commence welding until trial weld test sample, made with the equipment to be used passes trial weld test.
2. Clean geomembrane surface of grease, moisture, dust, dirt, debris, and other foreign material.
3. Overlap panels a minimum 3 inches for extrusion and 4 inches for hot wedge welding.
4. Do not use solvents or adhesives unless product is approved in writing by the OWNER.
5. Provide adequate material on weld to allow peel testing of both sides of double wedge weld.
6. Extend welding to the outside edge of all panels.
7. If required, provide a firm substrata by using a flat board, a conveyor belt, or similar hard surface directly under the weld overlap to achieve firm support.
8. Provide adequate illumination if welding operations are carried out at night,

and night operations are approved by the OWNER.

9. Cut fishmouths or wrinkles along the ridge of the wrinkle in order to achieve a flap overlap. Extrusion weld the cut fishmouths or wrinkles where the overlap is more than 3 inches. When there is less than 3 inches overlap, patch with an oval or round patch extending a minimum of 6 inches beyond the cut in all directions.
10. Log every 2 hours:
    a. Temperature directly on the geomembrane surface being welded.
    b. Extrudate temperatures in barrel and at nozzle (extrusion welder).
    c. Operating temperature of hot wedge (hot wedge welder) and any pressure adjustments made.
    d. Preheat temperature.
    e. Speed of hot wedge welder in feet per minute.
11. Weld only when ambient temperature, measured 6 inches above the geomembrane, is between 40°F (5°C) and 110°F (43°C).
12. If the INSTALLER seams at ambient temperatures below 40°F (5°C) or above 110°F (43°C), then the INSTALLER must demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced at ambient temperatures above 40°F (5°C) and below 110°F (43°C), and that the overall quality of the geomembrane is not adversely affected. In addition, a change order to the contract between the OWNER and the INSTALLER is required which specifically states that the seaming procedure does not cause any physical or chemical modification to the geomembrane that will generate any short or long term damage to the geomembrane. Then, the temperatures in the above quality assurance procedure will be modified accordingly.
13. Seaming below temperatures of 32°F must include preheating methods approved by the OWNER.

F. Defects and Repairs.

1. Examine all welds and non-weld areas of the geomembrane for defects, holes, blister, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane must be clean at the time of the examination.
2. Repair and non-destructively test each suspect location both in weld and non-weld areas. Do not cover geomembrane at locations which have been

repaired until test results with passing values are available.

G. Extrusion Type of Welding.
   1. Use procedures to tack bond adjacent panels together that do not damage geomembrane and allow CQA tests to be performed.
   2. Purge welding apparatus of heat-degraded extrudate before welding.
   3. Bevel top edges of geomembrane a minimum of 45° and full thickness of geomembrane before extrusion welding.
   4. Clean seam welding surfaces of oxidation by disc grinder or equivalent not more than 30 minutes before extruding weld. Change grinding discs frequently. Do not use clogged discs.
   5. Do not remove more than 4 mils of material when grinding.
   6. Grind across, not parallel to, welds.
   7. Cover entire width of grind area with extrudate.
   8. When restarting welding, grind ends of all welds that are more than 5-minutes old.

H. Hot Wedge Welding.
   1. Place smooth insulating plate or fabric beneath hot welding apparatus after usage.
   2. Protect against moisture build-up between panels.
   3. If welding cross seams, conduct field test welds at least every 2 hours, otherwise, once prior to start of work and once at mid-day.
   4. Bevel edges of top and bottom panels on cross seams.
   5. Do not weld on geomembrane until equipment has passed trial weld test.
   6. Extrusion-weld a repair patch over all seam intersections as described in Repair Procedures.

FIELD QUALITY CONTROL AND QUALITY ASSURANCE

A. Field Testing (Performed by INSTALLER).
   1. General: Non-destructively test all field seams over their full length using a vacuum test unit, air pressure (for double fusion seams only), spark testing, or other approved methods. Perform testing as the seaming progresses and not at the completion of all the field seaming. Complete all required repairs in accordance with this specification. INSTALLER needs to be informed when testing will be performed.

2. Vacuum Testing.
   a. Equipment:
      1) A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole, or valve assembly, and a vacuum gauge.
      2) A vacuum pump assembly equipped with a pressure control
      3) A rubber pressure/vacuum hose with fittings and connections.
      4) A soapy solution and an applicator.
   b. Test Procedures.
      1) Place the box over the wetted seam area (soapy solution).
      2) Ensure that a leak-tight seal is created.
      3) Energize the vacuum pump and reduce the vacuum box pressure to approximately 10 inches of mercury, i.e., 5 psi gauge.
      4) Examine the geomembrane through the viewing window for the presence of soap bubbles for a period of not less than 10 seconds.
      5) Mark all areas where soap bubbles appear and repair in accordance with repair procedures described in this specification.
3. Air pressure testing for seaming processes producing a double seam with an enclosed channel.
   a. Equipment, comprised of the following:
      1) An air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining a pressure over 40 psi and mounted on a cushion to protect the geomembrane.
      2) A rubber hose with fittings and connections.
      3) A sharp hollow needle, or other approved pressure feed device.
      4) A pressure gauge with an accuracy of plus or minus 1 psi.
   b. Test Procedures.
      1) Seal both ends of the welded seam to be tested.
      2) Insert needle or other approved pressure feed device into the

tunnel created by the weld.

3) Energize the air pump to a minimum pressure of 30 psi or 0.5 psi per mil of liner thickness, whichever is greater, close valve and sustain pressure for at least 5 minutes.

4) If loss of pressure exceeds 2 psi (10 mm mercury), or otherwise approved, or does not stabilize, locate faulty area and repair in accordance with repair procedures described in this specification.

5) Puncture opposite end of seam to release air. If blockage is present, locate and test seam on both sides of blockage.

6) Remove needle or other approved pressure feed device and seal the penetration holes.

4. Spark Testing for penetrations or other difficult areas not accessible for vacuum testing.

a. Equipment and Materials.

1) 24 gauge copper wire.

2) Low-amperage electric detector, 20,000 to 30,000 volt, with brush-type electrode capable of causing visible arc up to 3/4 inch from copper wire.

b. Procedures.

1) Place copper wire within 1/4 inch of the edge of extrusion seam or clamp seal.

2) Pass electrode over seam or clamp area and observe for spark. If a spark is detected perform a repair.

5. Destructive Testing (performed by CQA CONSULTANT and the INSTALLER).

a. Location and Frequency of Testing.

1) Collect destructive test samples at a minimum frequency of one test location per 500 feet of seam length.

2) Determine test locations during welding. Locations may be prompted by suspicion or excess crystallinity, contamination, offset welds, or suspected defect. CQA Monitor will be responsible for choosing the locations. CQA Monitor will not notify INSTALLER in advance of selecting locations where weld samples will be taken.

3) The CQA Monitor may increase the test frequency based on marginal results or other reasons deemed appropriate by the OWNER.

b. Sampling Procedures.

1) Cut samples at locations designated by the CQA Monitor as the welding progresses. Verify that laboratory test results have been obtained before the geomembrane is covered by another material.

2) CQA Monitor will number each sample and mark sample number and location in compliance with the CQA program.

3) Immediately repair all holes in the geomembrane resulting from destructive test sampling. Repair in accordance with repair procedures described in this document. Test the continuity of the repair in accordance with this document.

4) Size of Samples: minimum 12 inches wide by 44-inches-long with the seam centered lengthwise. Cut a 1-inch-wide strip from each end of the sample and test these for (shear and peel) in the field. Cut the remaining sample into three parts for distribution as follows:

- One portion for the INSTALLER: 12 inches by 12 inches for quality control testing.
- One portion for Construction Quality Assurance Laboratory: 12 inches by 18 inches for quality assurance testing.
- One portion to the OWNER for archive storage: minimum 12 inches by 12 inches.

c. Field Testing (Performed by INSTALLER).

1) Test the two, 1-inch-wide strips specified in Paragraph 4) above by tensiometer for peel and shear, respectively.

2) Both test strips must meet peel and shear requirements for welded seams specified in Table 1.

3) If any field test sample fails, follow failed test procedures outlined in this document.

D. Laboratory Testing performed independently by Construction Quality Assurance (CQA) Laboratory and INSTALLER.

1. Test "seam strength" and "peel adhesion" (ASTM D6392). Test 1-inch wide samples at strain rate of 2 inches per minute.
2. Minimum acceptable values to be obtained for these tests are specified in Table 1.
3. Test at least five specimens for each test method. Four of five specimens must meet minimum requirements. None of the peel specimens may peel 100 percent, or the entire sample will be considered as failing.
4. Select specimens alternately by test from the samples (i.e., peel, shear, peel, shear...).
5. Provide test results no more than 24 hours after receiving samples.
6. For double wedge welded samples, test both sides in peel.

E. Failed Weld Procedures.

1. Follow these procedures when there is a destructive test failure. Procedures apply when test failure is determined by the Construction Quality Assurance Laboratory, the INSTALLER, or by field tensiometer. Follow one of the following two options:
   a. First Option.
      - Reconstruct the seam between any two passing test locations. Can not extrusion weld flap.
   b. Second Option.
      - Trace the weld at least 10 feet minimum in both directions from the location of the failed test, or to the end of the weld.
      - Obtain a small sample at both locations for an additional field test.
      - If these additional test samples pass field tests, then take laboratory samples.
      - If the laboratory samples pass, then reconstruct the weld or cap between the two test sample locations that bracket the failed test location.
      - If any sample fails, then repeat the process to establish the zone in which the weld must be reconstructed.

F. Acceptable Welded Seams.

1. Bracketed by two locations from which samples have passed destructive tests.
2. For reconstructed seams exceeding 50 feet, a sample taken from within the

reconstructed weld passes destructive testing.

3. Whenever a sample fails, provide additional testing for seams that were welded by the same welder and welding apparatus or welded during the same time shift.

G. Seams That Cannot Be Non-Destructively Tested. Perform the following:

1. If the weld is accessible to testing equipment prior to final installation, non-destructively test the weld prior to final installation.
2. If the weld cannot be tested prior to final installation, cap strip the weld. The welding and cap-stripping operations must be observed by the CQA Monitor and INSTALLER for uniformity and completeness.

REPAIR PROCEDURES

A. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

B. Repair, removal, and replacement are at CONTRACTOR's expense if the damage results from the CONTRACTOR's, or the CONTRACTOR's subcontractor activities. Repair, removal, and replacement is at INSTALLER's expense if the damage results from the INSTALLER's, or the INSTALLER's subcontractor activities

C. Repair any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. Agreement upon the appropriate repair method will be determined between the OWNER's Representative, the CQA monitor, and the INSTALLER. Do not commence welding on liner until trial weld test sample, made by that equipment and operator, passes trial test. Repair procedures available include:

1. Patching: Used to repair large holes (over 0.375-inch diameter), tears (over 2-inches-long), undispersed raw materials, and contamination by foreign matter.
2. Abrading and re-welding: Used to repair small sections of seams.
3. Spot welding or seaming: Used to repair small tears (less than 2-inches-long), pin holes or other minor, localized flaws.
4. Capping: Used to repair long lengths of failed seams.
5. Removing the seam and replacing with a strip of new material.

D. In addition, satisfy the following procedures:

1. Abrade geomembrane surfaces to be repaired (extrusion welds only) no more

than one (1) hour prior to the repair.

2. Clean and dry all surfaces at the time of repair.
3. The repair procedures, materials, and techniques must be accepted in advance of the specific repair by the OWNER, CQA monitor, and INSTALLER.
4. Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of material to be patched and the patches to a radius of at least 3 inches.
5. Unless otherwise instructed by the OWNER, cut geomembrane below large caps to avoid water or gas collection between the sheets.

E. Verification of repair:

1. Number and log each repair.
2. Non-destructively test each repair using methods specified in Field Quality Control and Quality Assurance of this document.
3. Destructive tests may be required at the discretion of the OWNER.
4. Reconstruct repairs until tests indicate passing results.

GEOMEMBRANE ACCEPTANCE

A. INSTALLER retains all ownership and responsibility for the geomembrane until acceptance by the OWNER.

B. OWNER will accept geomembrane installation when:

1. All required documentation from the manufacturer, fabricator, and INSTALLER has been received and accepted.
2. The installation is finished.
3. Test reports verifying completion of all field seams and repairs, including associated testing, are in accordance with this document.
4. Written certification documents and drawings have been received by the OWNER.

SOIL PROTECTIVE LAYER

FINAL GRADING

A. Prepared subgrade (and soil cushion layer) shall be compacted to at least 90 percent of maximum dry density in accordance with ASTM D1557 or as required to meet the

requirements in the permit. Excavated areas not satisfying this requirement shall be over-excavated 6 inches or more as determined by the ENGINEER and backfilled with compacted soil material.

B. Remove any angular or sharp rocks and all debris from the completed subgrade surface.

C. Remove all observable rocks or clods greater than 0.5-inch in largest diameter from the completed subgrade surface.

D. Steel drum roll smooth all surfaces prior to placement of geosynthetics.

E. Grade subgrade to a vertical tolerance of plus or minus 0.10-foot.

F. Completed subgrade surface must have no vertical irregularities greater than 0.5-inch or abrupt grade transitions. The surface should provide for a continuous, intimate contact with the overlying geosynthetics.

G. All grade breaks must have a minimum radius of 1 foot.

H. Round corners of sumps and slope transitions into base of cell. Minimum radius: 1 foot, maximum radius: 2 feet (unless specified otherwise).

I. Before placing any materials in areas of the subgrade where excessive moisture is encountered, place a separator geotextile, gravel, and another geotextile separator (Note: pipes to drain the water may also be necessary). Contractor may need to dewater during construction.

J. Contractor is responsible for maintaining the prepared subgrade until the Installer has accepted the subgrade for the overlying materials.

K. After acceptance of subgrade, Contractor responsible for surface water control(s) so that runoff and/or runon do not damage already-deployed geosynthetics. Coordination with Installer is required.

L. If soil cushion cannot be placed on the side slopes, Contractor shall consult with OWNERE, and the subgrade shall receive gunite to receive geosynthetics.

FIELD QUALITY ASSURANCE

A. The OWNER will perform quality assurance testing during geosynthetics subgrade preparation consisting of:

1. Field density and moisture.
2. Moisture-density relationships.
3. Verify that angular or sharp rocks, and other debris that could damage the geomembrane are removed from the surface of the subgrade. Verify that the

subgrade is free of irregularities and is steel drum rolled smooth prior to geosynthetic placement.

4. Verify that the final surface provides continuous and intimate contact with the overlying geosynthetics.